

sPHENIX Calorimeter Electronics Review

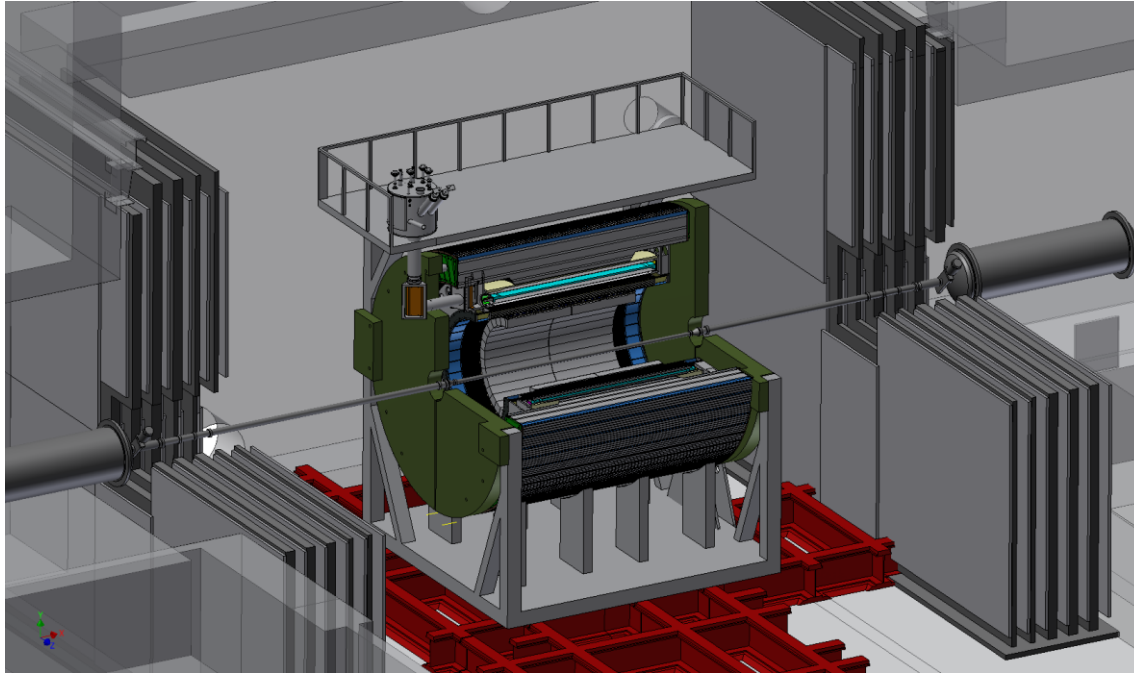
March 25, 2015

Brookhaven National Lab

Review Agenda

12:00	sPHENIX Project/Cal Elec. Org & Schedule(20+10)	Ed O'Brien
12:30	Calorimeter Electronics Overview(20+10)	Eric Mannel
1:00	SiPM Design and Testing Plan (20+10)	Sean Stoll
1:30	Analog Readout and Testing Plan (20+10)	Steve Boose
2:00	Break	
2:20	Digitizer Design and Testing Plan	Cheng Yi Chi
2:50	Integration and Prototyping Plan	John Haggerty
3:20	Executive session	
4:30	Close Out	

What is sPHENIX?



- **sPHENIX is a major upgrade to PHENIX. It is a new, large-acceptance, high-rate detector for HI physics to be built in the PHENIX hall.**
- **It will be optimized to measure jet and heavy quark physics by incorporating a vertex tracker, full EM and Hadronic Calorimeter coverage at $|\eta| < 1.1$, and a 1.5 T solenoidal magnetic field.**
- **It will utilize most of the infrastructure already existing in the PHENIX detector complex and the BaBar SC-magnet**

sPHENIX Detector and WBS

1.1 Project Management

1.2 Decommissioning

1.3 Magnet

1.4 Tracking

1.5 EM Calorimeter

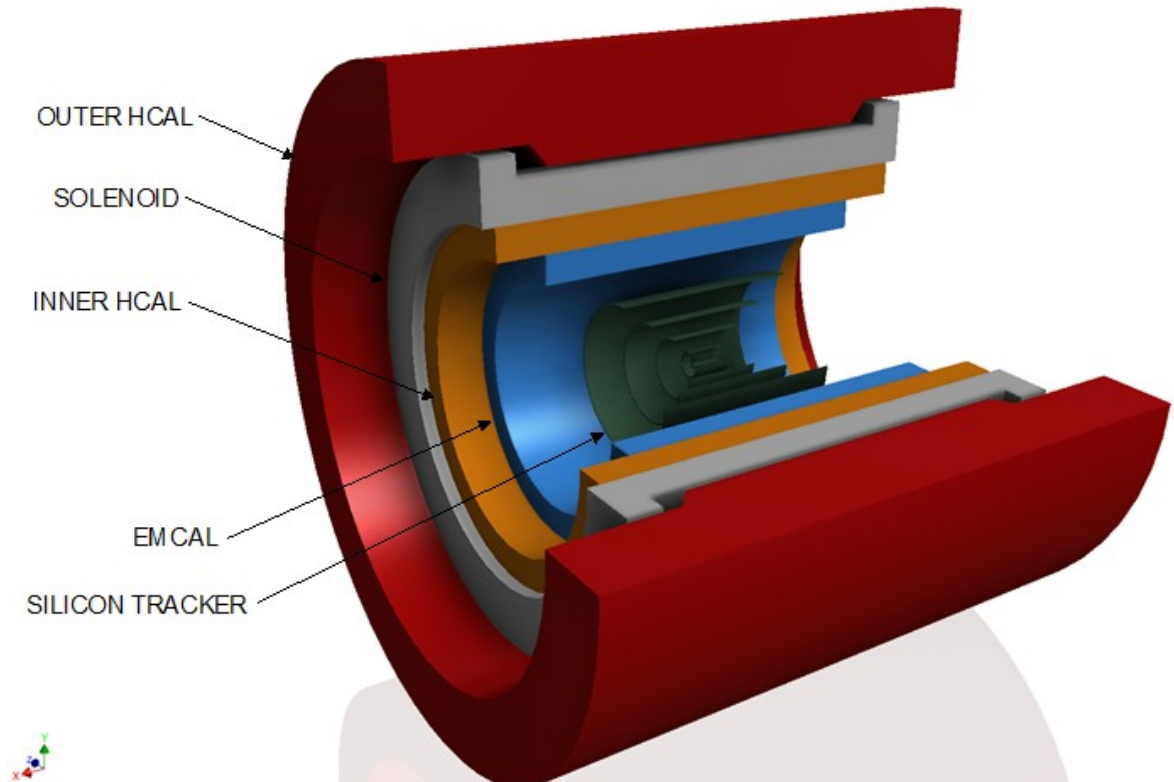
1.6 Hadronic Calorimeter

1.7 Calorimeter Electronics

1.8 DAQ/Trigger

1.9 Infrastructure

1.10 Integration and Installation



Anticipated sPHENIX Schedule

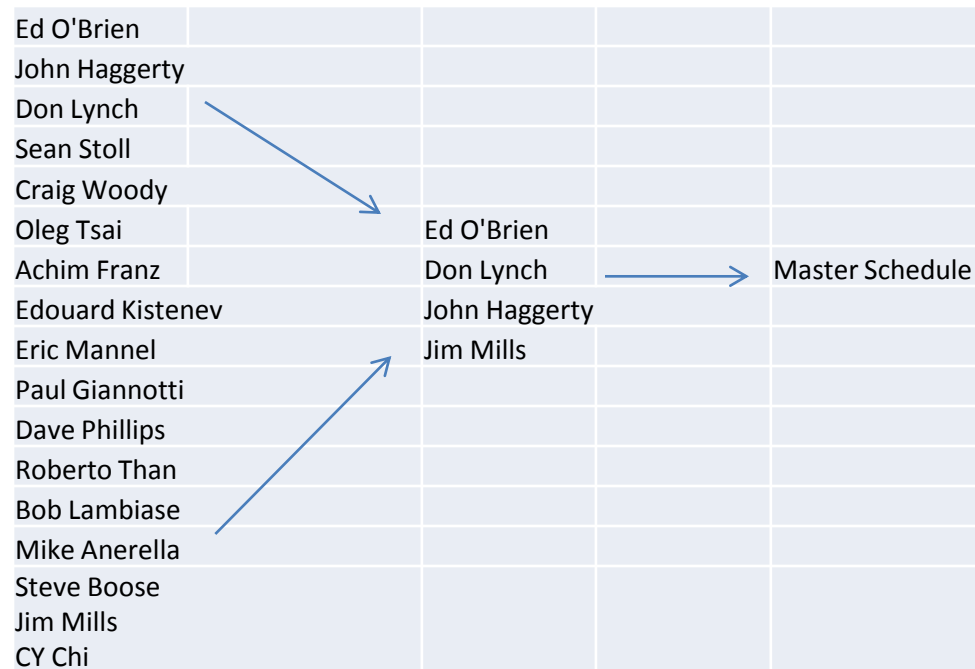
- **Original sPHENIX Proposal submitted to DOE Fall 2012**
- **DOE Science Review July 2014**
- **Revised Proposal Nov 2014**
- **DOE Science Review follow-up scheduled for April 30, 2015**
- **Expect CD-1 review summer 2015**
- **CD-1 approval Oct 2015**
- **CD-2/3 approval Oct 2016**
- **Decommissioning of existing PHENIX Detector July 2016 after RHIC Run-16**
- **Procurement of sPHENIX components begins late fall 2016**
- **Installation activities start Sept 2017 and continue through the end of 2020**
- **1st RHIC run with sPHENIX early 2021**

sPHENIX Project Plan Development

- **Bottoms-Up Schedule with Resources and Material Costs assigned each Task.**
 - Each subsystem expert assigned labor by category, fixed cost and duration
 - Used BNL labor bands for costs
 - Applied BNL extraordinary construction burden
- **All tasks are linked to create the schedule**
 - Critical path goes through the Outer HCal design and construction
- **Approximately 1000 Tasks in overall schedule.**
- **Prepared fall-2014**
- **Presently being scrubbed and checked by subsystem's reps.**

Project Plan Development

- Schedule/Resource development:



Project Status

- **We have the SC-magnet at BNL**
- **Conceptual reference design for much of the detector**
 - HCal, EMCal, Read Out electronics, DAQ/Trigger are making progress
 - Tracker at early stage (2 layers pixels from PHENIX, 5 new strip layers)
- **Much progress on both physics and detector performance simulations**
 - See sPHENIX proposal
- **Working toward CD-1**
 - WBS structure
 - Project file
 - Cost estimate
 - Labor profile
- **Cost Estimate yields a Total Project Cost \$55-60M fully burdened with 35% contingency**

Former BaBar Solenoid on the AGS Floor



March 25, 2015

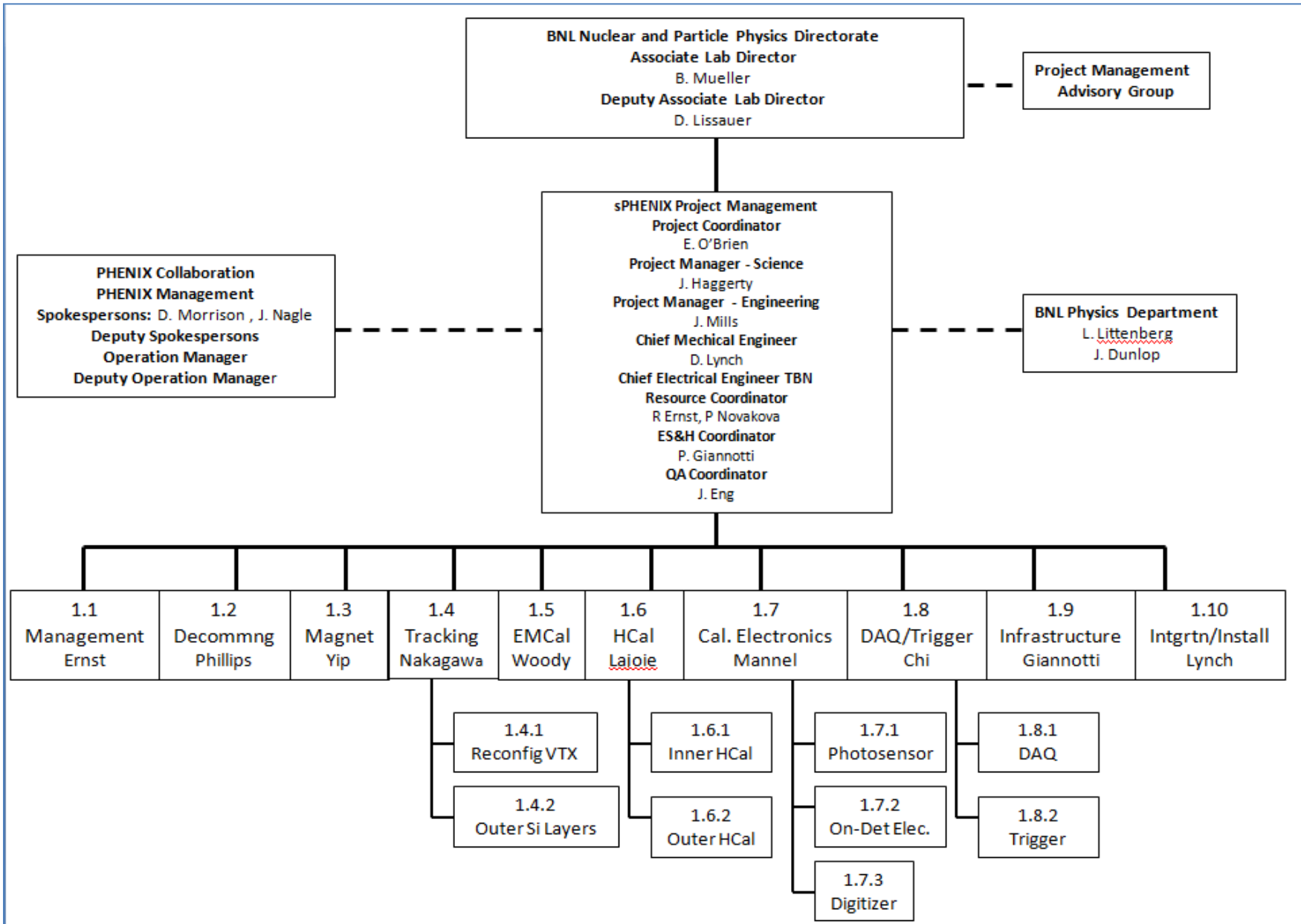
sPHENIX Calorimeter Electronics Review

Edward O'Brien

Documentation for CD-1 Review

- **WBS Established by Project team using input from subsystem experts.**
 - **WBS dictionary 90% complete**
 - **Outline exists for CDR**
 - **Draft of Quality Assurance Plan**
 - **Started on the NEPA**
 - **Information for bottoms-up contingency estimate has been collected but not yet completed**
 - **People are assigned to produce the various CD-1 documents**
- **WBS including Dictionary and Cost Book (Subsystem managers + Proj Controls Manager)**
 - **Conceptual Design Report (John H, Ed O'B, Brant Johnson)**
 - **Cost, Schedule and Labor estimates (John H, Ed O'B, Don L, Jim M, subsystem managers)**
 - **Basis of Estimate documents**
 - **Contingency Estimate – Bottoms up and risk based (Ed O'B, Jim M, Proj Controls Manager)**
 - **Project Execution Plan (Ed O'B, John H, Jim M)**
 - **Safety and Hazard Analysis (Paul Gianotti, Don L, C-AD ES&H)**
 - **Quality Assurance Plan (Jack E)**
 - **Acquisition Strategy (Bob E, Penka N)**
 - **Risk Analysis and Mitigation document (Jim M, Don L)**
 - **National Environmental Policy Act document (Jim M, C-AD ES&H)**
 - **Integrated Project Management Team document (JM EO'B)**

The Management Team



The Work Force

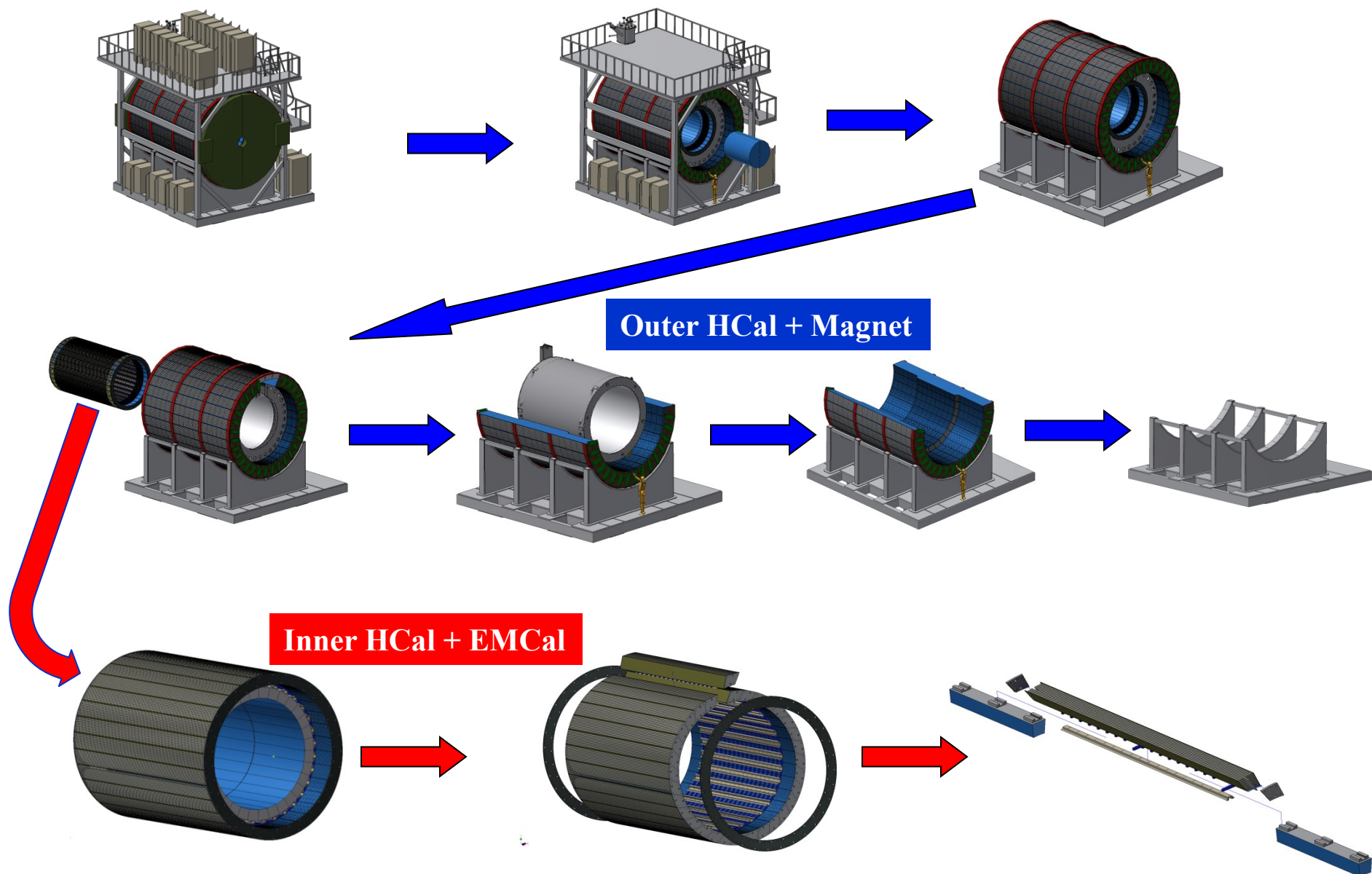
~ 30 person PHENIX Operations group

- Most with > 10 years experience on PHENIX, many on PHENIX 20 years**
- Appropriate mix of labor due to fact we have added ~\$25M of upgrades to PHENIX in the last 10 years**
- 9 Professional, 8.5 Technicians, 1.5 Designers, 10 FTE Scientists (additional 8.5 scientists supported at BNL by NP research funds), 1 Admin**
- sPHENIX construction also supported by C-AD and SMD especially for the Decommissioning, Magnet and Installation.**
- Additional engineering support provided by C-AD support for EMCal and Physics Dept for HCal.**
- Collaborating institutions participating or expressing interest in sPHENIX: UIUC, UMich, ISU, GSU, FSU, WSU, UCol, Nevis Labs, RIKEN, RBRC, Tsukuba, LANL, SBU, WIS, LLNL, UCLA, Yonsei**
- All students plus additional scientists and postdocs from universities**
- Additional funds being sought from NSF, Japan, Korea, LDRDs at other national labs.**

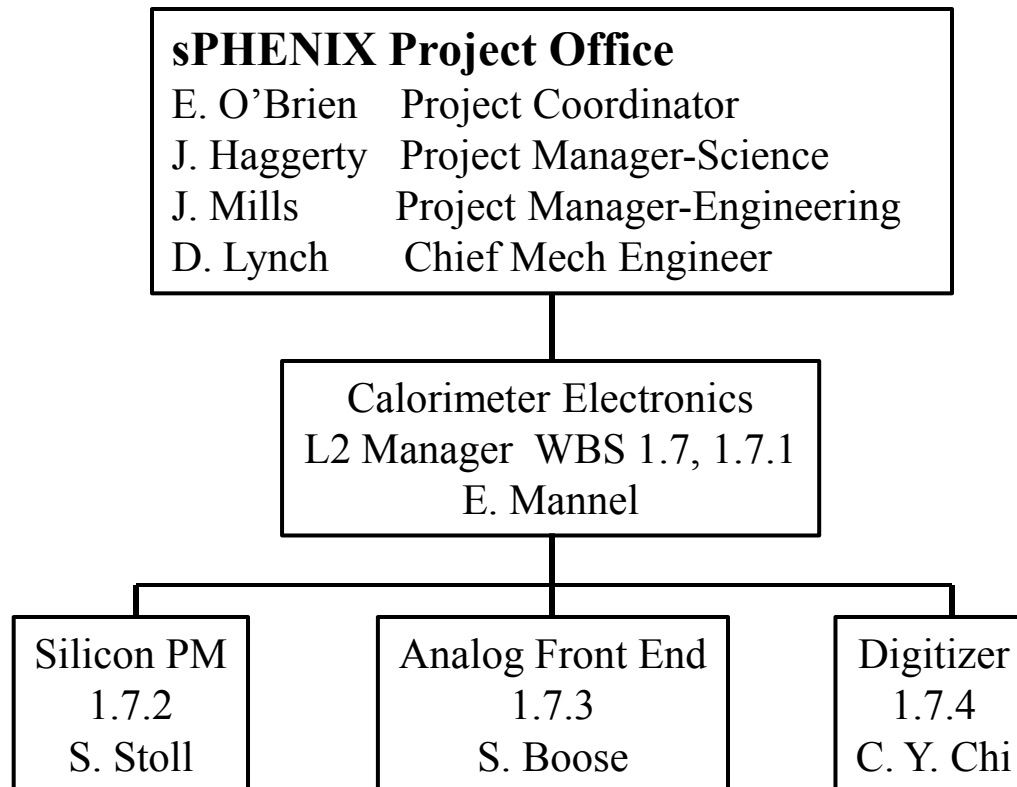
The Assembly Plan

- **Calorimeter electronics**
 - Digitizer designed, prototyped and fabbed by Columbia Univ, Nevis Labs
 - Analog front end designed, prototyped and fabbed by BNL Physics.
- **Outer HCal modules built at BNL**
 - Need to identify space at BNL for HCal fabrication and testing. We are looking at both 912 and 902 annex.
- **Inner HCal modules built at collaborating university**
 - Shipped to BNL for final testing and installation
- **EMCal modules built in industry and assembled and tested at collaborating universities**
 - Shipped to BNL for final testing and installation
- **Tracker staves built in Japan**
 - Assembly of barrel layers and testing at BNL
 - Need to identify space. We have an area in mind.

sPHENIX Deconstructed



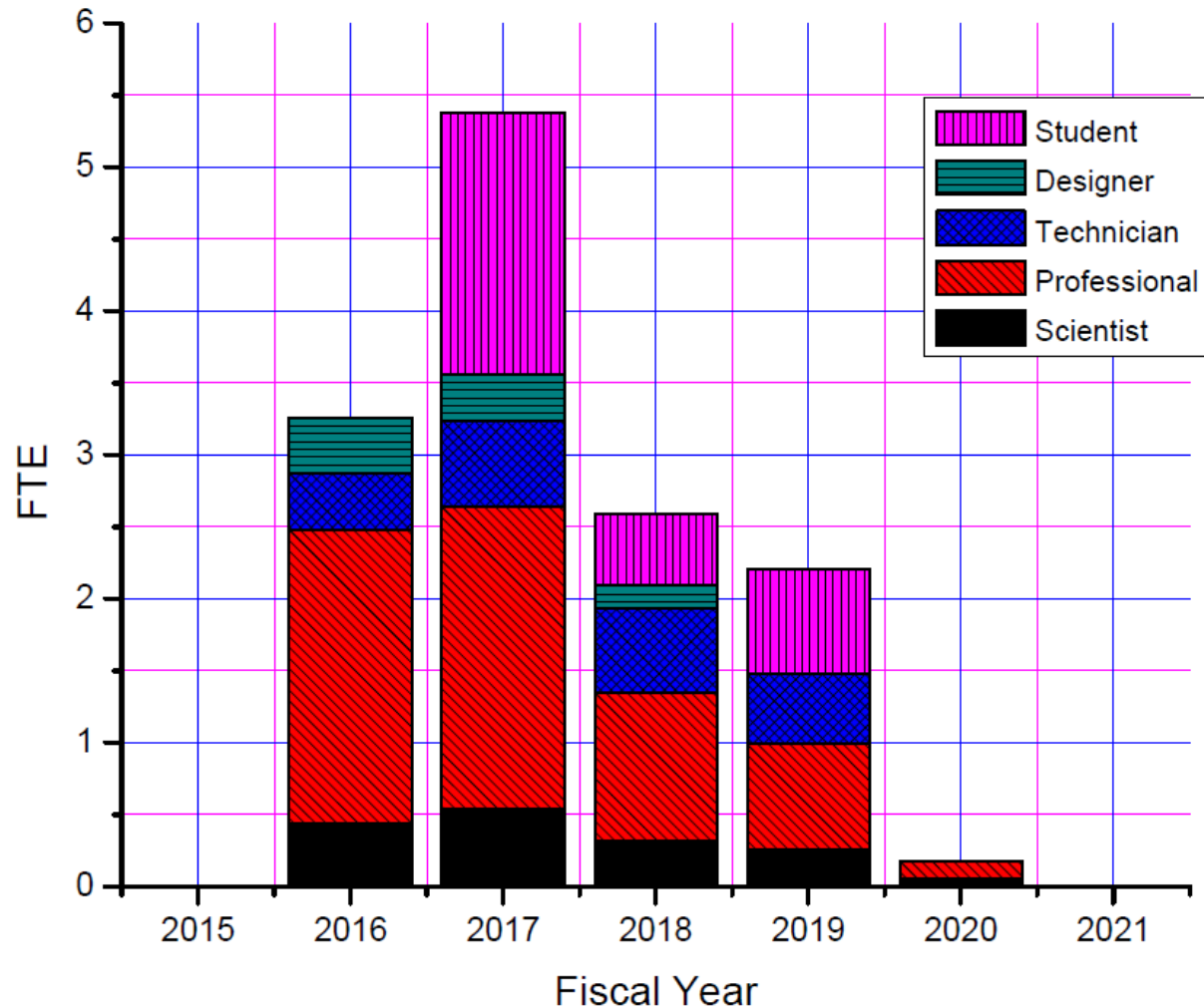
Calorimeter Electronics Organization



Note: EMCal is WBS 1.7, C. Woody is the L2 manager
HCal is WBS 1.6, J. Lajoie is the L2 manager
Infrastructure is WBS 1.9, P. Giannotti is the L2 manager

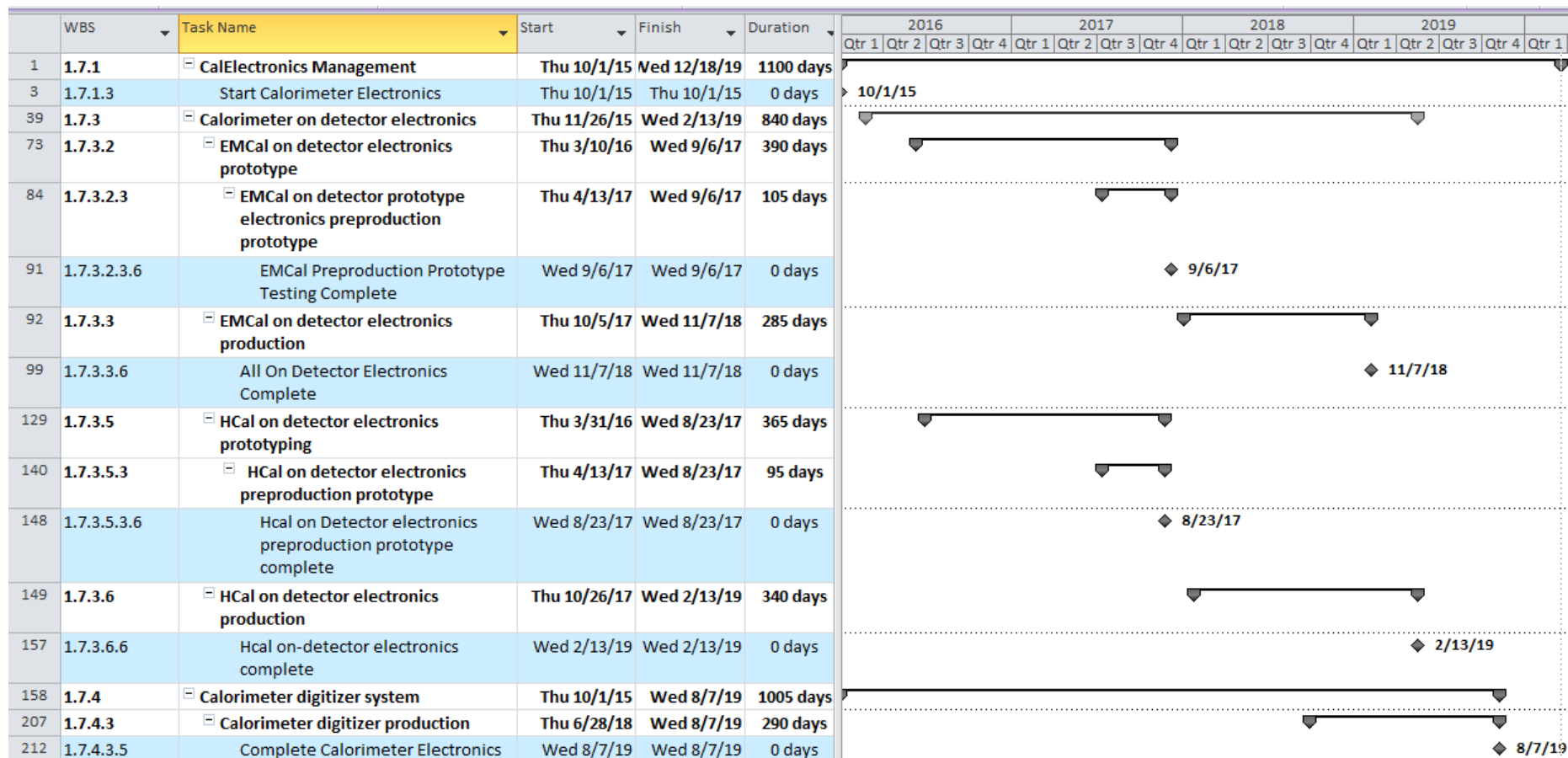
Calorimeter Electronics Labor Profile

sPHENIX Calorimeter Electronics Subsystem Resource Requirements
(Labor by Discipline)



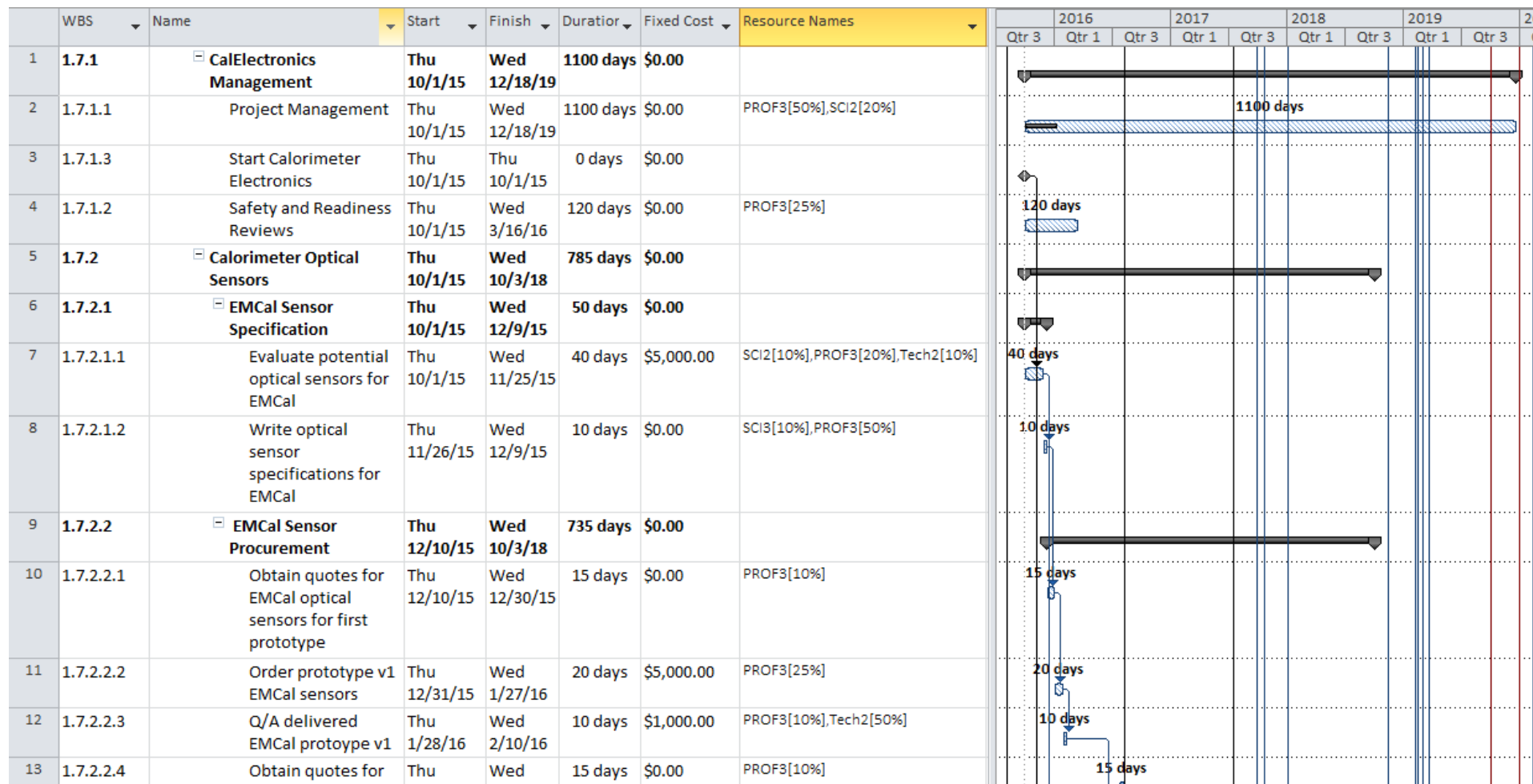
Specific individuals for these tasks have been identified with the exception of students. However we have a good idea which collaborating Universities will supply the students

Calorimeter Electronics Schedule and Milestones



Calorimeter Electronics Schedule with Material Costs

Resource-loaded schedule. Material and Labor costs included
No critical path tasks in WBS 1.7

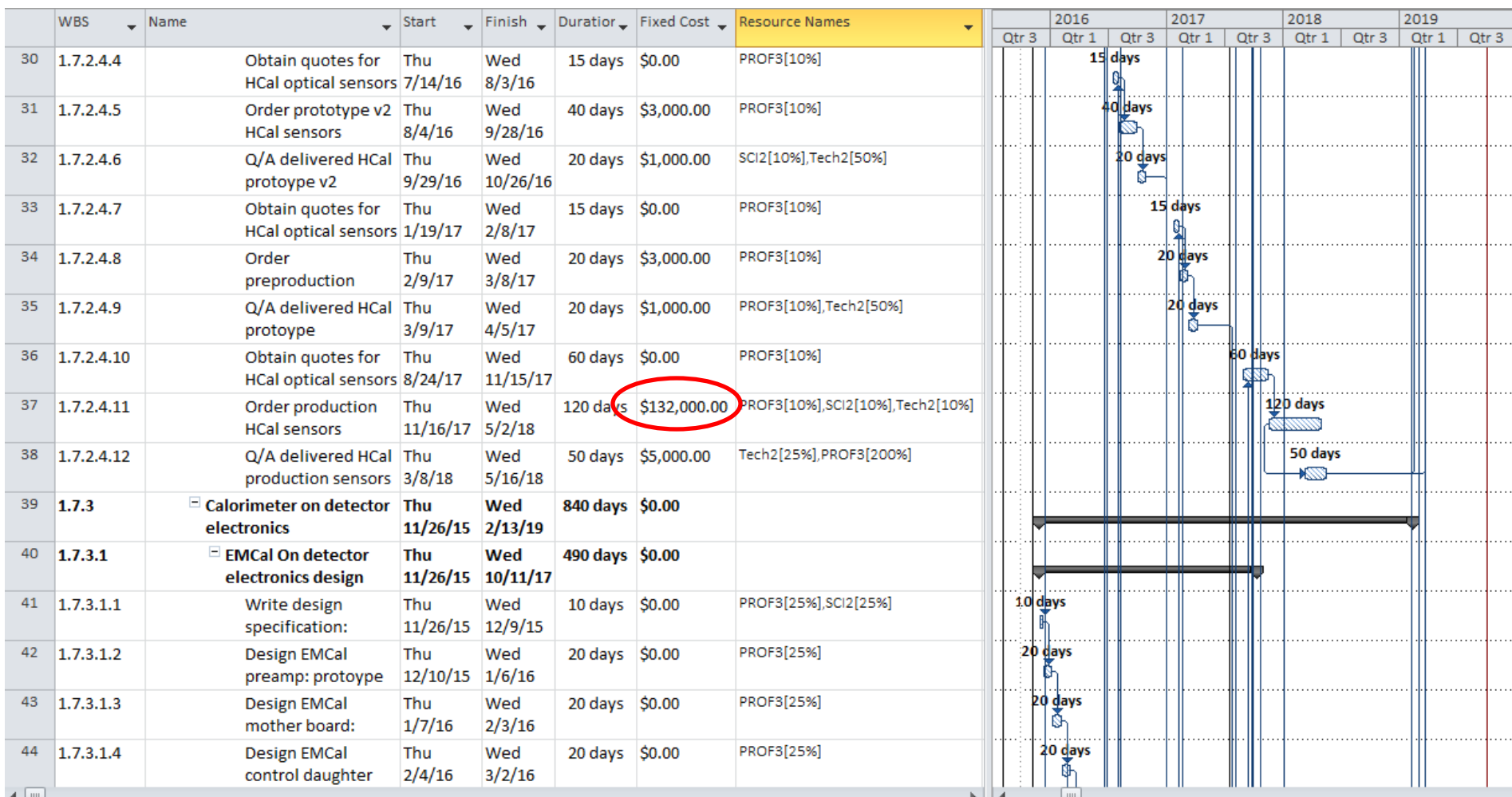


Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names	2016		2017		2018		2019	
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1
14	1.7.2.2.5	Order prototype v2 EMCal sensors	Thu 8/11/16	Wed 9/7/16	20 days	\$5,000.00	PROF3[25%]			20 days					
15	1.7.2.2.6	Q/A delivered EMCal prototype v2	Thu 9/8/16	Wed 10/5/16	20 days	\$1,000.00	PROF3[10%],Tech2[50%]			20 days					
16	1.7.2.2.7	Obtain quotes for EMCal optical	Thu 2/2/17	Wed 2/22/17	15 days	\$0.00	PROF3[10%]			15 days					
17	1.7.2.2.8	Order preproduction	Thu 2/23/17	Wed 3/22/17	20 days	\$5,000.00	PROF3[10%]			20 days					
18	1.7.2.2.9	Q/A delivered EMCal prototype	Thu 3/23/17	Wed 4/5/17	10 days	\$1,000.00	PROF3[10%],Tech2[50%]			10 days					
19	1.7.2.2.10	Obtain quotes for EMCal optical	Thu 9/7/17	Wed 10/4/17	20 days	\$0.00	PROF3[10%]			20 days					
20	1.7.2.2.11	Order production EMCal sensors	Thu 10/5/17	Wed 8/8/18	220 days	\$920,000.00	PROF3[10%]					220 days			
21	1.7.2.2.12	Q/A delivered EMCal production	Thu 12/28/17	Wed 10/3/18	200 days	\$5,000.00	PROF3[10%],Tech2[25%],STUDENT[2]					200 days			
23	1.7.2.3	<div>HCa1 Sensor Specification</div>	Thu 10/1/15	Wed 12/9/15	50 days	\$0.00									
24	1.7.2.3.1	Evaluate potential optical sensors for	Thu 10/1/15	Wed 11/25/15	40 days	\$5,000.00	SCI3[10%],PROF2[25%],Tech2[5%]			40 days					
25	1.7.2.3.2	Write optical sensor	Thu 11/26/15	Wed 12/9/15	10 days	\$0.00	PROF3[50%],SCI2[25%]			10 days					
26	1.7.2.4	<div>HCa1 Sensor Procurement</div>	Thu 12/10/15	Wed 5/16/18	635 days	\$0.00									
27	1.7.2.4.1	Obtain quotes for HCa1 optical sensors	Thu 12/10/15	Wed 12/30/15	15 days	\$0.00	PROF3[10%]			15 days					
28	1.7.2.4.2	Order prototype v1 HCa1 sensors	Thu 12/31/15	Wed 2/24/16	40 days	\$3,000.00	PROF3[10%]			40 days					
29	1.7.2.4.3	Q/A delivered HCa1 prototype v1	Thu 2/25/16	Wed 3/23/16	20 days	\$1,000.00	PROF3[10%],SCI3[10%],Tech2[50%]			20 days					

Costs based on discussions with Hamamatsu

Calorimeter Electronics Schedule with Material Costs



Costs based on discussions with Hamamatsu

Calorimeter Electronics Schedule with Material Costs

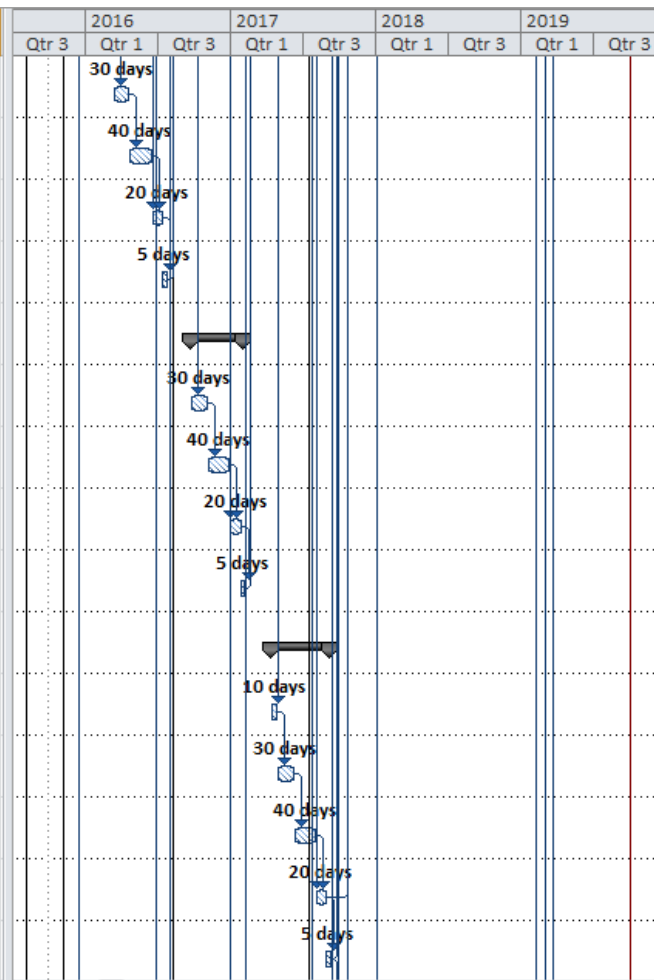
	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names	2016		2017		2018		2019		2020
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	
45	1.7.3.1.5	Layout EMCal motherboard:	Thu 2/4/16	Wed 2/24/16	15 days	\$0.00	Design1[50%],PROF3[10%]		15 days							
46	1.7.3.1.6	Layout EMCal controller	Thu 3/3/16	Wed 3/23/16	15 days	\$0.00	Design1[50%],PROF3[10%]		15 days							
47	1.7.3.1.7	Specify signal and power cables for	Thu 3/3/16	Wed 3/16/16	10 days	\$0.00	PROF3[25%],SCI2[25%]		10 days							
48	1.7.3.1.8	Specify power system for EMCal:	Thu 3/3/16	Wed 3/9/16	5 days	\$0.00	PROF3[25%]		5 days							
49	1.7.3.1.9	Review and write design	Thu 7/21/16	Wed 7/27/16	5 days	\$0.00	PROF3[25%],SCI2[25%]		5 days							
50	1.7.3.1.10	Design EMCal preamp: prototype	Thu 7/28/16	Wed 8/10/16	10 days	\$0.00	PROF3[25%]		10 days							
51	1.7.3.1.11	Design EMCal mother board:	Thu 8/11/16	Wed 8/24/16	10 days	\$0.00	PROF3[25%]		10 days							
52	1.7.3.1.12	Design EMCal control daughter	Thu 8/25/16	Wed 9/7/16	10 days	\$0.00	PROF3[25%]		10 days							
53	1.7.3.1.13	Layout EMCal motherboard:	Thu 8/25/16	Wed 9/7/16	10 days	\$0.00	Design1[50%],PROF3[10%]		10 days							
54	1.7.3.1.14	Layout EMCal controller	Thu 9/8/16	Wed 9/21/16	10 days	\$0.00	Design1[50%],PROF3[10%]		10 days							
55	1.7.3.1.15	Specify signal and power cables for	Thu 9/8/16	Wed 9/14/16	5 days	\$0.00	PROF3[25%],SCI2[25%]		5 days							
56	1.7.3.1.16	Specify power system for EMCal:	Thu 9/15/16	Wed 9/21/16	5 days	\$0.00	PROF3[25%]		5 days							
57	1.7.3.1.17	Review and write design	Thu 2/2/17	Wed 2/8/17	5 days	\$0.00	PROF3[25%],SCI2[25%]			5 days						
58	1.7.3.1.18	Design EMCal preamp:	Thu 2/9/17	Wed 2/15/17	5 days	\$0.00	PROF3[25%]			5 days						
59	1.7.3.1.19	Design EMCal mother board:	Thu 2/16/17	Wed 2/22/17	5 days	\$0.00	PROF3[25%]			5 days						

Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names	2016		2017		2018		2019	
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1
60	1.7.3.1.20	Design EMCal control daughter	Thu 2/23/17	Wed 3/1/17	5 days	\$0.00	PROF3[25%]				5 days				
61	1.7.3.1.21	Layout EMCal motherboard	Thu 3/2/17	Wed 3/15/17	10 days	\$0.00	Design1[50%],PROF3[10%]				10 days				
62	1.7.3.1.22	Layout EMCal controller	Thu 3/16/17	Wed 3/29/17	10 days	\$0.00	Design1[50%],PROF3[10%]				10 days				
63	1.7.3.1.23	Specify signal and power cables for	Thu 3/30/17	Wed 4/5/17	5 days	\$0.00	PROF3[25%]				5 days				
64	1.7.3.1.24	Specify power system for EMCal:	Thu 4/6/17	Wed 4/12/17	5 days	\$0.00	PROF3[25%]				5 days				
65	1.7.3.1.25	Review and write design	Thu 9/7/17	Wed 9/13/17	5 days	\$0.00	PROF3[25%],SCI2[25%]				5 days				
66	1.7.3.1.26	Design EMCal preamp: production	Thu 9/14/17	Wed 9/20/17	5 days	\$0.00	PROF3[25%]				5 days				
67	1.7.3.1.27	Design EMCal mother board:	Thu 9/21/17	Wed 9/27/17	5 days	\$0.00	PROF3[25%]				5 days				
68	1.7.3.1.28	Design EMCal control daughter	Thu 9/28/17	Wed 10/4/17	5 days	\$0.00	PROF3[25%]				5 days				
69	1.7.3.1.29	Layout EMCal motherboard:	Thu 9/28/17	Wed 10/11/17	10 days	\$0.00	Design1[50%],PROF3[10%]				10 days				
70	1.7.3.1.30	Layout EMCal controller	Thu 9/28/17	Wed 10/11/17	10 days	\$0.00	Design1[50%],PROF3[10%]				10 days				
71	1.7.3.1.31	Specify signal and power cables for	Thu 9/28/17	Wed 10/4/17	5 days	\$0.00	PROF3[25%]				5 days				
72	1.7.3.1.32	Specify power system for EMCal:	Thu 9/28/17	Wed 10/4/17	5 days	\$0.00	PROF3[25%]				5 days				
73	1.7.3.2	EMCal on detector electronics prototype	Thu 3/10/16	Wed 9/6/17	390 days	\$0.00									
74	1.7.3.2.1	EMCal on detector electronics	Thu 3/10/16	Wed 7/20/16	95 days	\$0.00									

Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names	2016		2017		2018		2019	
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1
75	1.7.3.2.1.1	Procure components:	Thu 3/10/16	Wed 4/20/16	30 days	\$15,000.00	PROF3[5%],Tech2[10%]		30 days						
76	1.7.3.2.1.2	Fabricate all boards:	Thu 4/21/16	Wed 6/15/16	40 days	\$5,000.00	PROF3[5%],Tech2[10%]		40 days						
77	1.7.3.2.1.3	Assemble and test prototype	Thu 6/16/16	Wed 7/13/16	20 days	\$5,000.00	SCI2[5%],PROF3[50%],Tech2[25%]		20 days						
78	1.7.3.2.1.4	Review and write design	Thu 7/14/16	Wed 7/20/16	5 days	\$0.00	PROF3[50%],SCI2[25%]		5 days						
79	1.7.3.2.2	EMCal on detector electronics	Thu 9/22/16	Wed 2/1/17	95 days	\$0.00									
80	1.7.3.2.2.1	Procure components:	Thu 9/22/16	Wed 11/2/16	30 days	\$7,500.00	PROF3[5%],Tech2[10%]		30 days						
81	1.7.3.2.2.2	Fabricate all boards:	Thu 11/3/16	Wed 12/28/16	40 days	\$5,000.00	PROF3[5%],Tech2[10%]		40 days						
82	1.7.3.2.2.3	Assemble and test prototype	Thu 12/29/16	Wed 1/25/17	20 days	\$5,000.00	SCI2[5%],PROF3[50%],Tech2[25%]		20 days						
83	1.7.3.2.2.4	Review and write design	Thu 1/26/17	Wed 2/1/17	5 days	\$0.00	PROF3[50%],SCI2[25%]		5 days						
84	1.7.3.2.3	EMCal on detector prototype	Thu 4/13/17	Wed 9/6/17	105 days	\$0.00									
85	1.7.3.2.3.1	Electrical safety review	Thu 4/13/17	Wed 4/26/17	10 days	\$0.00	Design1[25%],SCI2[10%],PROF3[10%]			10 days					
86	1.7.3.2.3.2	Procure components:	Thu 4/27/17	Wed 6/7/17	30 days	\$7,500.00	PROF3[5%],Tech2[10%]			30 days					
87	1.7.3.2.3.3	Fabricate all boards:	Thu 6/8/17	Wed 8/2/17	40 days	\$5,000.00	PROF3[5%],Tech2[10%]			40 days					
88	1.7.3.2.3.4	Assemble and test prototype	Thu 8/3/17	Wed 8/30/17	20 days	\$5,000.00	SCI2[5%],PROF3[50%],Tech2[25%]			20 days					
90	1.7.3.2.3.5	Review and write design	Thu 8/31/17	Wed 9/6/17	5 days	\$0.00	PROF3[50%],SCI2[25%]			5 days					



Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names	2016		2017		2018		2019	
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1
91	1.7.3.2.3.6	EMCal Preproduction	Wed 9/6/17	Wed 9/6/17	0 days	\$0.00									
92	1.7.3.3	EMCal on detector electronics production	Thu 10/5/17	Wed 11/7/18	285 days	\$0.00									
93	1.7.3.3.1	Production Readiness Review	Thu 10/5/17	Wed 10/18/17	10 days	\$0.00	PROF3[50%],SCI2[25%],Design1[25%]								
94	1.7.3.3.2	Procure components:	Thu 10/19/17	Wed 5/30/18	160 days	\$1,265,000.00	PROF3[5%],Tech2[10%]								
95	1.7.3.3.3	Fabricate all boards: production	Thu 2/8/18	Wed 9/19/18	160 days	\$134,000.00	PROF3[5%],Tech2[10%]								
96	1.7.3.3.4	Assemble electronics:	Thu 7/5/18	Wed 9/26/18	60 days	\$5,000.00	PROF3[10%],Tech2[50%],STUDENT								
97	1.7.3.3.5	Q/A EMCal electronics	Thu 8/16/18	Wed 11/7/18	60 days	\$5,000.00	PROF3[10%],Tech2[50%],STUDENT								
99	1.7.3.3.6	All On Detector Electronics	Wed 11/7/18	Wed 11/7/18	0 days	\$0.00									
100	1.7.3.4	HCal on detector electronics design	Thu 11/26/15	Wed 10/25/17	500 days	\$0.00									
101	1.7.3.4.1	Write Design specifications:	Thu 11/26/15	Wed 12/9/15	10 days	\$0.00	PROF3[50%],SCI2[50%]								
102	1.7.3.4.2	Design HCal preamp: prototype	Thu 12/10/15	Wed 1/6/16	20 days	\$0.00	PROF3[50%],SCI2[10%]								
103	1.7.3.4.3	Design HCal controller board:	Thu 1/7/16	Wed 2/3/16	20 days	\$0.00	PROF3[50%]								
104	1.7.3.4.4	Layout HCal preamp: prototype	Thu 1/7/16	Wed 2/3/16	20 days	\$0.00	PROF3[10%],Design1[50%]								
105	1.7.3.4.5	Layout Hcal controller board:	Thu 2/4/16	Wed 3/2/16	20 days	\$0.00	PROF3[10%],Design1[50%]								
106	1.7.3.4.6	Specify signal and power cables:	Thu 2/4/16	Wed 3/2/16	20 days	\$0.00	PROF3[50%]								

Costs based on engineering estimates derived from prototype costs

Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names	2016		2017		2018		2019		
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	
107	1.7.3.4.7	Design HCal power system: prototype	Thu 3/3/16	Wed 3/30/16	20 days	\$0.00	PROF3[50%]		20 days							
108	1.7.3.4.8	Review and write Design	Thu 7/14/16	Wed 7/27/16	10 days	\$0.00	PROF3[50%],SCI2[50%]		10 days							
109	1.7.3.4.9	Design HCal preamp: prototype	Thu 7/28/16	Wed 8/10/16	10 days	\$0.00	PROF3[25%],SCI2[5%]		10 days							
110	1.7.3.4.10	Design HCal controller board:	Thu 8/11/16	Wed 8/24/16	10 days	\$0.00	PROF3[50%]		10 days							
111	1.7.3.4.11	Layout HCal preamp: prototype	Thu 8/11/16	Wed 8/24/16	10 days	\$0.00	PROF3[10%],Design1[50%]		10 days							
112	1.7.3.4.12	Layout HCal controller board:	Thu 8/25/16	Wed 9/7/16	10 days	\$0.00	PROF3[10%],Design1[50%]		10 days							
113	1.7.3.4.13	Specify signal and power cables:	Thu 9/8/16	Wed 9/21/16	10 days	\$0.00	PROF3[50%]		10 days							
114	1.7.3.4.14	Design HCal power system: prototype	Thu 9/22/16	Wed 10/5/16	10 days	\$0.00	PROF3[50%]		10 days							
115	1.7.3.4.15	Review and write Design	Thu 1/19/17	Wed 2/1/17	10 days	\$0.00	PROF3[50%],SCI2[50%]		10 days							
116	1.7.3.4.16	Design HCal preamp:	Thu 2/2/17	Wed 2/15/17	10 days	\$0.00	PROF3[50%],SCI2[50%]		10 days							
117	1.7.3.4.17	Design HCal controller board:	Thu 2/16/17	Wed 3/1/17	10 days	\$0.00	PROF3[50%]		10 days							
118	1.7.3.4.18	Layout HCal preamp:	Thu 2/16/17	Wed 3/1/17	10 days	\$0.00	PROF3[10%],Design1[50%]		10 days							
119	1.7.3.4.19	Layout HCal controller board:	Thu 3/2/17	Wed 3/15/17	10 days	\$0.00	PROF3[10%],Design1[50%]		10 days							
120	1.7.3.4.20	Specify signal and power cables:	Thu 3/16/17	Wed 3/29/17	10 days	\$0.00	PROF3[50%]		10 days							
121	1.7.3.4.21	Design HCal power system:	Thu 3/30/17	Wed 4/12/17	10 days	\$0.00	PROF3[50%]		10 days							

Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names												
								2016				2017		2018		2019			
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3			
122	1.7.3.4.22	Write Design specifications: Hcal	Thu 8/24/17	Wed 9/6/17	10 days	\$0.00	PROF3[50%],SCI2[50%]					10 days							
123	1.7.3.4.23	Design HCal preamp: production	Wed 8/30/17	Wed 9/13/17	10 days	\$0.00	PROF3[50%],SCI2[50%]					10 days							
124	1.7.3.4.24	Design HCal controller board:	Thu 9/14/17	Wed 9/27/17	10 days	\$0.00	PROF3[50%]					10 days							
125	1.7.3.4.25	Layout HCal preamp: production	Thu 9/14/17	Wed 9/27/17	10 days	\$0.00	PROF3[10%],Design1[50%]					10 days							
126	1.7.3.4.26	Layout HCal controller board:	Thu 9/28/17	Wed 10/11/17	10 days	\$0.00	PROF3[10%],Design1[50%]					10 days							
127	1.7.3.4.27	Specify signal and power cables:	Thu 10/12/17	Wed 10/25/17	10 days	\$0.00	PROF3[25%]					10 days							
128	1.7.3.4.28	Design HCal power system: production	Thu 10/12/17	Wed 10/25/17	10 days	\$0.00	PROF3[25%]					10 days							
129	1.7.3.5	[-] HCal on detector electronics	Thu 3/31/16	Wed 8/23/17	365 days	\$0.00													
130	1.7.3.5.1	[-] HCal on detector electronics	Thu 3/31/16	Wed 7/13/16	75 days	\$0.00													
131	1.7.3.5.1.1	Procure components:	Thu 3/31/16	Wed 5/11/16	30 days	\$10,000.00	PROF3[5%],Tech2[10%]			30 days									
132	1.7.3.5.1.2	Fabricate boards: HCal prototype	Thu 5/12/16	Wed 6/22/16	30 days	\$5,000.00	PROF3[5%],Tech2[10%]			30 days									
133	1.7.3.5.1.3	Assemble and test HCal	Thu 6/23/16	Wed 7/6/16	10 days	\$1,000.00	SCI2[10%],PROF3[50%],Tech2[50%]			10 days									
134	1.7.3.5.1.4	Review and write design	Thu 7/7/16	Wed 7/13/16	5 days	\$0.00	SCI2[25%],PROF3[25%]			5 days									
135	1.7.3.5.2	[-] HCal on detector electronics	Thu 10/6/16	Wed 1/18/17	75 days	\$0.00													
136	1.7.3.5.2.1	Procure components:	Thu 10/6/16	Wed 11/16/16	30 days	\$7,500.00	PROF3[5%],Tech2[10%]			30 days									

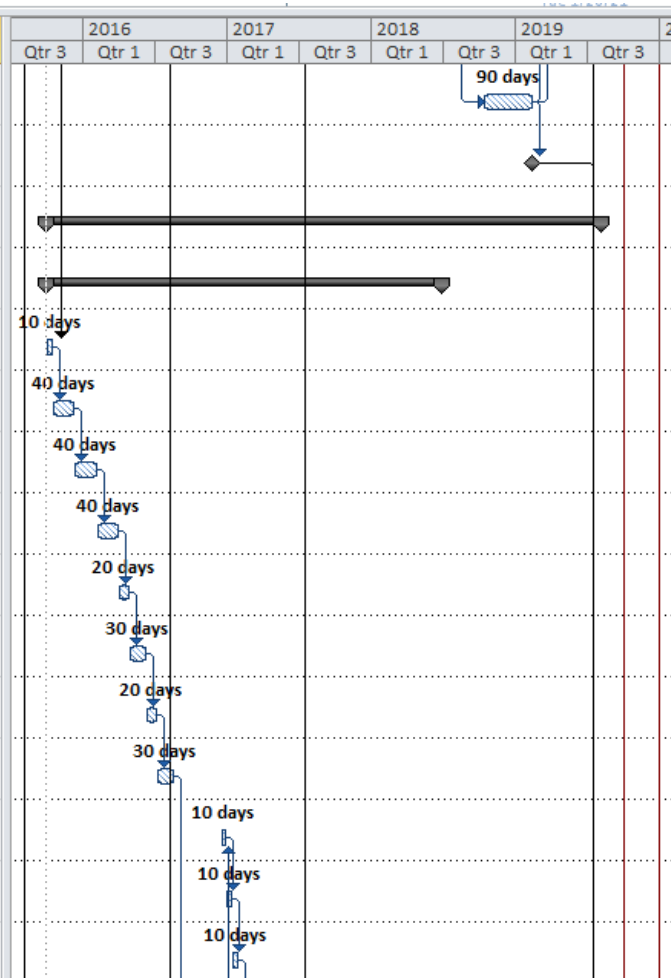
Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names										
								2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1
137	1.7.3.5.2.2	Fabricate boards: HCal prototype	Thu 11/17/16	Wed 12/28/16	30 days	\$5,000.00	PROF3[5%],Tech2[10%]										
138	1.7.3.5.2.3	Assemble and test HCal	Thu 12/29/16	Wed 1/11/17	10 days	\$1,000.00	SCI2[10%],PROF3[25%],Tech2[50%]										
139	1.7.3.5.2.4	Review and write design	Thu 1/12/17	Wed 1/18/17	5 days	\$0.00	SCI2[25%],PROF3[25%]										
140	1.7.3.5.3	HCal on detector electronics	Thu 4/13/17	Wed 8/23/17	95 days	\$0.00											
141	1.7.3.5.3.1	Electrical Safety Review	Thu 4/13/17	Wed 4/26/17	10 days	\$0.00	PROF3[50%],SCI2[25%],Design1[25%]										
142	1.7.3.5.3.2	Procure components:	Thu 4/27/17	Wed 6/7/17	30 days	\$7,500.00	PROF3[5%],Tech2[10%]										
143	1.7.3.5.3.3	Fabricate boards: HCal	Thu 6/8/17	Wed 7/19/17	30 days	\$5,000.00	PROF3[5%],Tech2[10%]										
144	1.7.3.5.3.4	Assemble and test HCal	Thu 7/20/17	Wed 8/16/17	20 days	\$1,000.00	SCI2[10%],PROF3[25%],Tech2[50%]										
147	1.7.3.5.3.5	Review and write design	Thu 8/17/17	Wed 8/23/17	5 days	\$0.00	SCI2[25%],PROF3[25%]										
148	1.7.3.5.3.6	Hcal on Detector electronics	Wed 8/23/17	Wed 8/23/17	0 days	\$0.00											
149	1.7.3.6	HCal on detector electronics production	Thu 10/26/17	Wed 2/13/19	340 days	\$0.00											
150	1.7.3.6.1	Production Readiness Review	Thu 10/26/17	Wed 11/8/17	10 days	\$0.00	PROF3[50%],SCI2[25%],Design1[25%]										
151	1.7.3.6.2	Procure components: HCal	Thu 10/26/17	Wed 3/14/18	100 days	\$175,000.00	PROF3[5%],Tech2[10%]										
152	1.7.3.6.3	Fabricate boards: HCal production	Thu 3/15/18	Wed 8/29/18	120 days	\$11,200.00	PROF3[5%],Tech2[10%]										
153	1.7.3.6.4	Assemble HCal electronics:	Thu 8/30/18	Wed 11/21/18	60 days	\$5,000.00	PROF3[5%],Tech2[50%],STUDENT										

Costs based on engineering estimates derived from prototype costs

Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names												
								2016				2017		2018		2019			
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3			
154	1.7.3.6.5	Q/A HCal on-detector	Thu 10/11/18	Wed 2/13/19	90 days	\$5,000.00	PROF3[5%],Tech2[50%],STUDENT										90 days		
157	1.7.3.6.6	Hcal on-detector electronics	Wed 2/13/19	Wed 2/13/19	0 days	\$0.00													
158	1.7.4	Calorimeter digitizer system	Thu 10/1/15	Wed 8/7/19	1005 days	\$0.00													
159	1.7.4.1	Calorimeter digitizer design	Thu 10/1/15	Wed 6/27/18	715 days	\$0.00													
160	1.7.4.1.1	Write design specifications for	Thu 10/1/15	Wed 10/14/15	10 days	\$0.00	PROF3[50%],SCI2[50%]												
161	1.7.4.1.2	Design Digitizer Boards: Prototype	Thu 10/15/15	Wed 12/9/15	40 days	\$0.00	PROF3[50%]												
162	1.7.4.1.3	Design Clock Master Board:	Thu 12/10/15	Wed 2/3/16	40 days	\$0.00	PROF3[50%]												
163	1.7.4.1.4	Design XMIT Board: Prototype v1	Thu 2/4/16	Wed 3/30/16	40 days	\$0.00	PROF3[50%]												
164	1.7.4.1.5	Design Crate: Prototype V1	Thu 3/31/16	Wed 4/27/16	20 days	\$0.00	PROF3[50%]												
165	1.7.4.1.6	Layout Digitizer Board: Prototype v1	Thu 4/28/16	Wed 6/8/16	30 days	\$0.00	PROF3[10%],Design1[50%]												
166	1.7.4.1.7	Layout Crate Controller Board:	Thu 6/9/16	Wed 7/6/16	20 days	\$0.00	PROF3[10%],Design1[50%]												
167	1.7.4.1.8	Layout XMIT Board: Prototype v1	Thu 7/7/16	Wed 8/17/16	30 days	\$0.00	PROF3[10%],Design1[50%]												
168	1.7.4.1.9	Review and write design change	Thu 12/15/16	Wed 12/28/16	10 days	\$0.00	PROF3[50%],SCI2[25%]												
169	1.7.4.1.10	Design Digitizer Boards: Prototype	Thu 12/29/16	Wed 1/11/17	10 days	\$0.00	PROF3[50%]												
170	1.7.4.1.11	Design Clock Master Board:	Thu 1/12/17	Wed 1/25/17	10 days	\$0.00	PROF3[50%]												



Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names	2016		2017		2018		2019	
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1
171	1.7.4.1.12	Design XMIT Board: Prototype v2	Thu 1/26/17	Wed 2/8/17	10 days	\$0.00	PROF3[50%]				10 days				
172	1.7.4.1.13	Design Crate: Prototype v2	Thu 2/9/17	Wed 2/22/17	10 days	\$0.00	PROF3[50%]				10 days				
173	1.7.4.1.14	Layout Digitizer Board: Prototype v2	Thu 2/23/17	Wed 3/8/17	10 days	\$0.00	PROF3[10%],Design1[50%]				10 days				
174	1.7.4.1.15	Layout Clock Master Board: Prototype v2	Thu 3/9/17	Wed 3/22/17	10 days	\$0.00	PROF3[10%],Design1[25%]				10 days				
175	1.7.4.1.16	Layout XMIT Board: Prototype v2	Thu 3/23/17	Wed 4/5/17	10 days	\$0.00	PROF3[10%],Design1[50%]				10 days				
176	1.7.4.1.17	Write design change	Thu 8/3/17	Wed 8/16/17	10 days	\$0.00	PROF3[50%],SCI2[25%]				10 days				
177	1.7.4.1.18	Design Digitzer Boards:	Thu 8/17/17	Wed 8/30/17	10 days	\$0.00	PROF3[50%]				10 days				
178	1.7.4.1.19	Design Clock Master Board:	Thu 8/31/17	Wed 9/13/17	10 days	\$0.00	PROF3[50%]				10 days				
179	1.7.4.1.20	Design XMIT Board: Preproduction	Thu 9/14/17	Wed 9/27/17	10 days	\$0.00	PROF3[50%]				10 days				
180	1.7.4.1.21	Design Crate: Preproduction	Thu 9/28/17	Wed 10/11/17	10 days	\$0.00	PROF3[50%]				10 days				
181	1.7.4.1.22	Layout Digitizer Board:	Thu 10/12/17	Wed 10/25/17	10 days	\$0.00	PROF3[10%],Design1[50%]				10 days				
182	1.7.4.1.23	Layout Clock Master Board:	Thu 10/26/17	Wed 11/8/17	10 days	\$0.00	PROF3[10%],Design1[50%]				10 days				
183	1.7.4.1.24	Layout XMIT Board: Preproduction	Thu 11/9/17	Wed 11/22/17	10 days	\$0.00	PROF3[10%],Design1[50%]				10 days				
184	1.7.4.1.25	Write design change	Thu 4/5/18	Wed 4/18/18	10 days	\$0.00	PROF3[25%],SCI2[25%]					10 days			
185	1.7.4.1.26	Design XMIT Board: Production	Thu 4/19/18	Wed 5/2/18	10 days	\$0.00	PROF3[50%]					10 days			

Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names																
								2016				2017				2018				2019			
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3					
186	1.7.4.1.27	Design Crate: Preproduction	Thu 5/3/18	Wed 5/16/18	10 days	\$0.00	PROF3[50%]																
187	1.7.4.1.28	Layout Digitizer Board: Production	Thu 5/17/18	Wed 5/30/18	10 days	\$0.00	PROF3[10%],Design1[50%]																
188	1.7.4.1.29	Layout Clock Master Board: Production	Thu 5/31/18	Wed 6/13/18	10 days	\$0.00	PROF3[10%],Design1[50%]																
189	1.7.4.1.30	Layout XMIT Board: Production	Thu 6/14/18	Wed 6/27/18	10 days	\$0.00	PROF3[10%],Design1[50%]																
190	1.7.4.2	Calorimeter Digitizer prototype	Thu 8/18/16	Wed 4/4/18	425 days	\$0.00																	
191	1.7.4.2.1	Calorimeter digitizer prototype	Thu 8/18/16	Wed 12/14/16	85 days	\$0.00																	
192	1.7.4.2.1.1	Procure components for	Thu 8/18/16	Wed 9/28/16	30 days	\$40,000.00	Tech2[10%]																
193	1.7.4.2.1.2	Fabricate Boards for digitizer	Thu 9/29/16	Wed 11/9/16	30 days	\$30,000.00	Tech2[10%]																
194	1.7.4.2.1.3	Assemble and test digitizer	Thu 11/10/16	Wed 12/7/16	20 days	\$1,000.00	PROF3[25%],SCI2[25%],Tech2[25%]																
195	1.7.4.2.1.4	Review and write design	Thu 12/8/16	Wed 12/14/16	5 days	\$0.00	PROF3[25%],SCI2[25%]																
196	1.7.4.2.2	Calorimeter digitizer prototype	Thu 4/6/17	Wed 8/2/17	85 days	\$0.00																	
197	1.7.4.2.2.1	Procure components for	Thu 4/6/17	Wed 5/17/17	30 days	\$30,000.00	Tech2[10%]																
198	1.7.4.2.2.2	Fabricate Boards for digitizer	Thu 5/18/17	Wed 6/28/17	30 days	\$30,000.00	Tech2[10%]																
199	1.7.4.2.2.3	Assemble and test digitizer	Thu 6/29/17	Wed 7/26/17	20 days	\$0.00	PROF3[25%],SCI2[25%],Tech2[25%]																
200	1.7.4.2.2.4	Review and write design	Thu 7/27/17	Wed 8/2/17	5 days	\$0.00	PROF3[25%],SCI2[25%]																

Cost based on R&D work under an existing contract with Nevis

Calorimeter Electronics Schedule with Material Costs

	WBS	Name	Start	Finish	Duration	Fixed Cost	Resource Names									
								2016			2017		2018		2019	
								Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3	Qtr 1	Qtr 3
201	1.7.4.2.3	Calorimeter digitizer	Thu 11/23/17	Wed 4/4/18	95 days	\$0.00										
202	1.7.4.2.3.1	Electrical Safety Review	Thu 11/23/17	Wed 12/6/17	10 days	\$0.00	PROF3[50%],SCI2[25%]						10 days			
203	1.7.4.2.3.2	Procure components for	Thu 12/7/17	Wed 1/17/18	30 days	\$30,000.00	Tech2[10%]						30 days			
204	1.7.4.2.3.3	Fabricate Boards for digitizer	Thu 1/18/18	Wed 2/28/18	30 days	\$30,000.00	Tech2[10%]						30 days			
205	1.7.4.2.3.4	Assemble and test digitizer	Thu 3/1/18	Wed 3/28/18	20 days	\$0.00	PROF3[25%],SCI2[25%],Tech2[25%]						20 days			
206	1.7.4.2.3.5	Review and write design	Thu 3/29/18	Wed 4/4/18	5 days	\$0.00	PROF3[25%],SCI2[25%]						5 days			
207	1.7.4.3	Calorimeter digitizer production	Thu 6/28/18	Wed 8/7/19	290 days	\$0.00										
208	1.7.4.3.1	Production Readiness Review	Thu 6/28/18	Wed 7/11/18	10 days	\$0.00	PROF3[50%],SCI2[25%],Design1[25%]						10 days			
209	1.7.4.3.2	Procure components for	Thu 7/12/18	Wed 12/26/18	120 days	\$900,000.00	PROF3[5%],Tech2[10%]						120 days			
210	1.7.4.3.3	Fabricate Boards for digitizer system:	Thu 12/27/18	Wed 6/12/19	120 days	\$380,000.00	PROF3[5%],Tech2[10%]							120 days		
211	1.7.4.3.4	Assemble and test digitizer production	Thu 6/13/19	Wed 8/7/19	40 days	\$0.00	SCI2[10%],Tech2[25%],PROF3[25%]								40 days	
212	1.7.4.3.5	Complete Calorimeter	Wed 8/7/19	Wed 8/7/19	0 days	\$0.00										

Cost based on existing R&D contract with Nevis

Cost based on fab of a similar board for PHENIX by Nevis

Calorimeter Electronics WBS Dictionary

1. Project Title:	2. Date:	3. Person Responsible
SPHENIX	3/17/2015	E. Mannel

4. WBS Element Code	5. WBS Element Title
1.07.01	Calorimeter Electronics Oversight and Management

6. Index Line Number:	7. Revision Number and Authorization:	8. Rev. Date

9. Approved Changes

9. Element Task Description
<p><u>COST CONTENT:</u></p> <p>Labor cost only, no material. Labor based on subsystem engineer with 10% of time spent on project management.</p> <p><u>TECHNICAL SCOPE:</u></p> <p>Level 2 Engineer overseeing and managing the design, prototyping and production of EMCal and HCal front end and back end electronics. Responsibilities include budgeting, preparation of reports and presentations.</p> <p><u>WORK STATEMENT:</u></p> <p>Provide management and oversight of the design, prototyping and production of the electronics for the sPHENIX EMCal and HCal electronics. Specific tasks include:</p> <ol style="list-style-type: none"> 1. Produce and monitor overall schedule for all aspects of the design, prototyping and production of the sPHENIX EMCal and HCal electronics to make sure that all milestones are met on schedule. 2. Provide overall management of procurement activities and monitoring of expenditures for the sPHENIX EMCal and HCal electronics 3. Work with scientific and engineering staff to produce all technical design documents. Review documentation to make sure that the design will achieve the performance needed to meet the scientific goals of sPHENIX. 4. Participate in project reviews: <ol style="list-style-type: none"> a. Assist with producing review documents. b. Make presentations at project reviews when requested. 5. Organize and schedule technical design, prototype performance and production readiness reviews for the sPHENIX EMCal and HCal electronics.

Calorimeter Electronics WBS Dictionary

1. Project Title:	2. Date:	3. Person Responsible
SPHENIX	3/17/2015	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.02	EMCal Sensor Procurement

6. Index Line Number:	7. Revision Number and Authorization:	8. Rev. Date

9. Approved Changes

9. Element Task Description
<u>COST CONTENT:</u> Labor costs are based on an engineer working 10 to 25% of time obtaining quotes, submitting purchase requisitions, monitoring delivery and overseeing testing of prototype and production sensors. Technician time for setting up and testing of prototype (50%) and production (25%) sensors. Student time at 100% for testing of production sensors.
<u>TECHNICAL SCOPE:</u> Engineer to manage the procurement and testing of optical sensors needed for all prototypes and production of the EMCal. Technician to assist with setting up and testing optical sensors for prototypes and production EMCal detectors. Students to assist in the testing and sorting of production sensors for the EMCal.
<u>WORK STATEMENT:</u> This task covers the procurement and Q/A testing of all optical sensors for the EMCal: <ol style="list-style-type: none">1. Obtain quotes for EMCal optical sensors for all prototyping stages and production.2. Submit orders for EMCal optical sensors for all prototyping stages and production.3. Monitor delivery of EMCal optical sensors.4. Design test procedures for Q/A acceptance.5. Test SiPMs for Q/A acceptance and sort production sensors based on performance criteria. Deliverables are optical sensors for prototype EMCal electronics testing and production EMCal electronics.

Tracking Past Review Recommendations

No Calorimeter Electronics action items from Previous reviews

Issues and Concerns

- **SiPMs look promising but its vulnerability to rad damage is a concern.**
- **Do we need to develop a back-up technical solution like APDs?**
- **There are a number of issues where work is just starting: Cooling, cabling and access for maintenance**
- **Testing plans need more development especially the for the production quantities of SiPMs (> 100k) and analog front ends.**
- **Need to create more documentation such as Cost Book, CDR, PEP...**

Back Up

sPHENIX is Built on the Foundation of PHENIX

sPHENIX is a major upgrade to the PHENIX experiment, built on \$10M's of infrastructure assembled over twenty years

Existing:

- **Support buildings: Counting house, electronic rack room, Assembly Hall, IR, PS and service buildings, office space, meeting rooms, etc.**
- **Mechanical: rails, crane, shield wall, cooling**
- **Electrical: substation, transformers, power distribution, grounding**
- **Safety systems**
- **Data acquisition computing and networking**
- **Work areas**
- **Extensive gas pad, large dewars including 3k gallon LN₂, proximity to RHIC cryo**
- **HVAC, environmental controls, high capacity ventilation**